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PATENT

UNITED STATES PATENT APPLICATION

of

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for a

METHOD AND APPARATUS FOR COOLING A SELF-CONTAINED LASER HEAD

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A similar method taught by Hill et al in U.S. Patent 4,096,450 uses two separate cooling systems where one cooling system cools a flashlamp via conduction by surrounding a portion of the lamp with barium sulfate powder. The other system cools a laser rod by circulating coolant around the rod.

SUMMARY OF THE INVENTION

Problems described in the prior art *supra*, and others, are solved by applicant's invention of providing a single cooling system capable of cooling not only a laser and the laser components, but the system level components in the laser imaging system including the laser power supply and laser light valve. Further, the cooling system is capable of cooling components of a laser imaging system that present different thermal loads to the cooling system.

An object of the invention herein is to provide a single cooling system capable of cooling a laser, a laser power supply, and a laser light valve simultaneously.

A further object of the invention herein is to provide a single cooling system capable of cooling multiple thermal loads requiring different degrees of cooling.

A further object of the invention herein is to provide a single cooling system that precludes premature laser failure due to overheating of the laser.

Another object of the invention is to provide thermal protection for a laser in the event a coolant flow problem arises in any portion of the cooling system.

Laser 20 may be of the semiconductor type that employs multiple emitters to produce a single high power laser beam 23 though it is not limited to being a semiconductor laser. Solid state lasers such as Nd:YAG, gas lasers or even dye lasers may be used in lieu of laser 20. The main difference being the required coolant flow for each type of laser is different. Laser 20 is cooled by circulating a cooling fluid through small cooling channels formed into a cooling block (not shown) that is part of laser 20.

A single circulating unit 35 has a tank 40 containing a cooling fluid (alternatively referred to as coolant) which is preferably de-ionized water. The cooling fluid (not shown) is cooled by a refrigeration unit 50. The coolant is circulated through laser 20, laser power supply 25, light valve 15 and back into tank 40 using circulating pump 45. Circulating unit 35 may be stationary and separate from the laser head 3.

Laser 20 and laser power supply 25 require different rates of flow of cooling fluid through each component. Laser 20 requires a flow rate as low as about 0.13 gallons per minute (GPM) depending on the type of laser. Laser power supply 25 requires a higher flow rate of about 0.5 GPM.

The invention herein provides two parallel coolant supply paths to the laser 20 and laser power supply 25, each coolant supply path having a different flow rate.

First parallel coolant supply path 70 is connected between coolant supply port 37 located on circulating unit 35, and coolant inlet port 22 of laser 20. Coolant outlet port 21 of laser 20 is serially connected to flow rate sensor 55 via inlet port 56. Outlet port 57 of flow rate sensor 55 is connected to a coolant return port 36 of circulating unit 35 wherein the coolant is returned to the tank 40. Since no flow restriction devices or other flow control means are deposited in the laser cooling loop, the flow rate is determined by the size and number of the cooling channels within laser 20. Flow rate sensor 55, which may be a digital or analog sensor, or alternatively, a simple flow switch, provides a signal to controller (or

microprocessor) 30 representative of a coolant flow rate through laser 20 via connection 68.

Low coolant flow within laser 20 is a known failure mode and often occurs as a result of debris or organic growth within the small channels formed into the cooling block integral to laser 20 (not shown). Flow rate sensor 55 is deployed in the manner described in order to detect such a condition.

If the rate of flow of cooling fluid through laser 20, as detected by flow rate sensor 55, falls below a predetermined value, controller 30 sends a signal to power supply 25 via interface 29, causing power supply 25 to remove electrical power from laser 20 via connection 24. Alternatively, or in addition to shutting down laser 20, controller 30 may alert an operator via a visual or audio alert means 80 such as a light, computer graphic, buzzer, bell etc.

Second parallel coolant supply path 75 is connected between coolant supply port 37 located on circulating unit 35, and coolant inlet port 67 of flow control valve 65. Flow control valve 65, such as a type manufactured by Dole, Part Number 1407096, is preset to a predetermined flow rate, is self regulating and provides a constant rate of flow of coolant to light valve 15, and power supply 25 independent of pressure.

Coolant outlet port 66 of flow control valve 65 is serially connected to coolant inlet port 16 of light valve 15. Coolant outlet port 17 of light valve 15 is serially connected to coolant inlet port 26 of laser power supply 25. Coolant outlet port 27 of laser power supply 25 is serially connected to on/off valve 60 via coolant inlet port 61. Outlet port 62 of on/off valve 60 is connected to coolant return port 36 of circulating unit 35 wherein the coolant is returned to the tank 40.

On/off valve 60 provides the ability to shut off the supply of coolant to second parallel coolant supply path 75. This allows for purging of the cooling system 1.

Laser power supply 25 has temperature monitoring circuitry 28 for measuring the temperature of laser power supply 25. If temperature monitoring circuitry 28 measures a temperature that exceeds a predetermined value, temperature monitoring circuitry 28 causes power supply 25 to remove electrical power from laser 20 via connection 24.

For example, if a blockage occurs at coolant outlet port 27 of laser power supply 25, the temperature of laser power supply 25 begins to increase. Temperature monitoring circuitry 28 detects the increase in temperature and removes electrical power from laser 20 via connection 24 when the temperature of laser power supply 25 exceeds a predetermined limit. Further, laser power supply 25 may shut itself down after removing power from laser 20. A blockage occurring anywhere in second parallel coolant supply path 75 is addressed in the same manner.

Similarly, a blockage occurring anywhere in first parallel coolant supply path 70 is detected and addressed by flow rate sensor 55 and controller 30 as described *supra*.

Though the invention herein is described with reference to imaging machines in the graphic arts industry, the invention is not restricted to use in the graphics industry and may be used wherever a laser system requires cooling.

Those skilled in the art will appreciate that numerous modifications and variations may be made to the above disclosed embodiments without departing from the spirit and scope of the present invention.